REPORT OF THE

DEFENSE SCIENCE BOARD
TASK FORCE

ON

SUBMARINE OF THE FUTURE

July 1998

OFFICE OF THE UNDER SECRETARY OF DEFENSE
FOR ACQUISITION & TECHNOLOGY
WASHINGTON, D.C. 20301-3140

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DEFENSE SCIENCE
BOARD

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE (ACQUISITION & TECHNOLOGY)

SUBJECT: Final Report of the Defense Science Board Task Force on Submarine of the Future

I am forwarding the final report of the Defense Science Board Task Force on Submarine of the Future.

This report examines how nuclear attack submarines (SSNs) best serve the nation's future defense needs. The Terms of Reference directed that emphasis be placed on operational utility of future generations of submarines (beyond the New Attack Submarine (NSSN)) and the impact of the littoral environment on submarine design and operation in the context of joint operations.

The Task Force quickly recognized that near term decisions concerning submarines will impact their use in our naval forces over the next 50 years and that a very long view of submarine technologies and missions is needed. In consequence of this conclusion the Task Force presents three primary recommendations:

1. The NSSN should continue and evolve leading to a next generation submarine in about 2020 that is large, possesses a nuclear propulsion plant similar to the NSSN, and contains a new, flexible payload interface with the water. This last item, the payload interface, is an example of the Task Force central theme of devoting design effort to the "front end" of the submarine.

2. For existing submarines, the number of submarines required to maintain one submarine on station (called the "K" factor), can be improved to meet deployment requirements, but possibly at the cost of reactor core lifetime. The Task Force recommends measures to improve this ratio, although not at the expense of diverting innovative design efforts from the "front end."

3. Initiate immediately a wide open look at future submarine and applicable undersea and information technologies with a concerted DARPA/Navy effort. Additionally, the improved ability of the government to measure the ship's

performance can be exploited during the operational life of the ship to incorporate improvements.

The Task Force believes that early implementation of its recommendations can put in place a set of processes that will assure the United States of a continuing leadership position in submarine technology and submarine operational capabilities.

I endorse the Task Force's recommendations and propose you review the Task Force Chairman's letter and report.

Craig Fields
Chairman

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
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DEFENSE SCIENCE BOARD

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Final Report of the Defense Science Board Task Force on Submarine of the Future

Attached is the report of the Defense Science Board Task Force on Submarine of the Future. This study was requested by the Under Secretary of Defense for Acquisition and Technology. The Terms of Reference directed that emphasis be placed on operational utility of future generations of submarines (beyond the New Attack Submarine (NSSN)) and the impact of the littoral environment on submarine design and operation in the context of joint operations. The guidance provided in the Terms of Reference focused attention on the future naval environment, the role of the submarine, potential new submarine capabilities, and processes for developing any new technologies that may be needed by future submarines.

The Task Force quickly recognized that near term decisions concerning submarines will impact their use in our naval forces over the next 50 years and that a very long view of submarine technologies and missions is needed if this study is to be useful to DoD and to the Navy. In this long view, the Task Force concludes that the emerging politico-military environment and the rapidly changing technology environment are such that the nuclear attack submarine will remain an essential and enduring element of our naval force structure. The unique combination of stealth, mobility, endurance and versatile offensive power have no valid competitor in the set of missions to which attack submarines apply today or in the foreseeable future. In consequence of this conclusion the Task Force presents three primary recommendations (and has provided the draft implementing memoranda to make clear the intent of the recommendations):

1. The NSSN should continue and evolve leading to a next generation submarine in about 2020 with the following properties:
   - A large nuclear submarine
   - Propulsion plant similar to the NSSN plant
   - A new flexible weapons interface with the water
2. For existing submarines, the number of submarines required to maintain one submarine on station (called the "K" factor), can be improved to meet deployment

requirements, but possibly at the cost of reactor core lifetime.

- The Task Force endorses such measures but cautions they should not be allowed to exacerbate an already serious inventory problem.
- Include in the next generation SSN an improved K factor with potential extensions of SSN life that are possible without change to the back end of the boat.

3. Initiate immediately a wide open look at future submarine and applicable technologies with a concerted DARPA/Navy effort by:
   - Navy executing platform development
   - Maximizing industrial inputs
   - Using performance measurement techniques to maximum extent possible to stimulate intellectual competition of ideas. The improved ability of the government to measure performance can be exploited during the operational life of the ship to incorporate improvements.

The Task Force believes that early implementation of its recommendations can put in place a set of processes that will assure the United States of a continuing leadership position in submarine technology and submarine operational capabilities and will serve to ensure the best technologies for submarines on an affordable basis.

The Task Force is especially appreciative of the support provided by its advisors and of the generous contribution of time and intellectual input from the many briefers and from senior Navy leadership knowledgeable of submarine operations and technologies.

I thank the Task Force members and the talented group of government advisors for their hard work and valuable insights.

John Stenbit

John Stenbit
Task Force Chairman

THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-3010

ACQUISITION AND TECHNOLOGY

APR 23 1997

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference--Defense Science Board Task Force on Submarine of the Future

You are requested to establish a Defense Science Board (DSB) Task Force to assess how attack submarines should serve the nation's defense needs in the 21st century.

The winning of the Cold War—an outcome to which US submarines contributed significantly—has led to a shift in the structure and the employment of all our armed forces. In particular, the Department of Defense has been forced to truncate the SEAWOLF program in favor of a smaller, more flexible, more affordable platform. The imminent start of New Attack Submarine (NSSN) construction marks an appropriate juncture for an assessment of the operational utility of the subsequent generations of attack submarines.

The US is no longer confronted by a one-dimensional threat, but by several actual and potential widely distributed regional threats; this has brought about a shift in the Navy's focus from open water to littoral regions, and the Task Force should concentrate its attention on that circumstance. A submarine's stealth is especially valuable in that environment, as sophisticated weapons proliferate and make it increasingly difficult for surface ships to operate near an adversary's shoreline.

There continues to be a strong movement toward "jointness" among the armed services, as urged by the Goldwater-Nichols legislation, and exemplified by the call for seamless integration made by the Chairman of the Joint Chiefs of Staff in *Joint Vision 2010*. The Task Force should explore the submarine's contribution to joint operations in the littoral. Significant resources are being expended to improve that capability: cruise missile attack against distant inland targets; intelligence collection; surveillance and reconnaissance; early warning of threat developments; mine delivery or minefield mapping; and covert insertion/extraction of special operations forces.

It is expected that there will be a continuing shrinkage of the resources allocated to US defense. The Task Force should

examine unit cost/capability tradeoffs in considering the design of a submarine force appropriate to the future environments in which naval warfare may occur. In exploring all of these issues, the Task Force should examine the broadest range of alternatives and be guided by the following questions:

- What is the naval environment to be expected for the next 10 - 20 years?
- What is the role of the Navy in the next 10 - 20 years?
- What is the role of submarines?
- What then is the ideal submarine or submarine force mix?
- Why do submarines need more capability than they have today?
- What new roles might be considered for a radically different submarine and what might their characteristics be to effect this paradigm shift?
- What are the technology improvement barriers that need to be overcome for very significant improvement of the ideal submarine force mix or radically different submarines?

The Task Force should report its findings by the end of Calendar Year 1997. An interim briefing of major findings should be provided in September 1997 to allow meaningful input to any new submarine initiatives in PR99.

The Director, Strategic and Tactical Systems and Director, Defense Advanced Research Projects Agency will sponsor this Task Force and provide funding and other support as may be necessary. Mr. John P. Stenbit will serve as the Task Force Chairman. Dr. Paris Genalis, Deputy Director, OUSD(A&T) Office of Naval Warfare, will serve as the Executive Secretary and CDR David Norris, USN, will serve as the Defense Science Board Secretariat representative.

The Task Force will be operated in accordance with the provisions of P.L. 92-463, the "Federal Advisory Committee Act," and DoD Directive 5105.4, the "DoD Federal Advisory Committee Management Program." It is not anticipated that this Task Force will need to go into any "particular matters" within the meaning of Section 208 of Title 18, U.S. Code, nor will it cause any member to be placed in the position of acting as a procurement official.

Paul Kaminski

Paul G. Kaminski

Defense Science Board
Task Force on
Submarine of the Future

Mr. John Stenbit, Chairman
Dr. Paris Genalis, Executive Secretary

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INTRODUCTION

This report format is a reproduction of the final briefing charts with additional short commentary on each chart.

SUMMARY

- SSNs are a key and enduring element of the current and future naval force - a "crown jewel" in America's arsenal
- We need more, not fewer SSNs
- Near term, invest in/evolve the front end and payload of the sub, not the propulsion.
- DoD needs to widen participation and reallocate tasks in the research, development, and acquisition of SSNs

Based on the military and technological forecasts on which it has been briefed, the Task Force concludes that nuclear attack submarines (SSNs) will remain an enduring element of the naval force structure.

The SSN force level forecasts based on budget expectations are noted to be substantially lower than those recommended by the QDR, and the United States may require more, not fewer SSNs.

The traditional emphasis on advances in SSN propulsion and quieting must shift to connectivity, sensors, weapons, adjuvant vehicles, and interfaces with the water.

Because of their uniqueness, the only real testing of these systems will come from ourselves, not competition with other nations' programs. To maintain our lead position, the government must inject dynamic performance verification to spur the rapid detection of shortcomings.

TASK FORCE MEMBERSHIP

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Dr. Paris Genalis, OSD(A&T)/S&TS/NW, Executive Secretary

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Mr. Jim Woolsey, Shea & Gardner

ABSTRACT OF TERMS OF REFERENCE

- What is the naval environment to be expected for the next 10-20 years?
- What is the role of the Navy in the next 10-20 years?
- What is the role of submarines?
- What then is the ideal submarine or submarine force mix?
- Why do submarines need more capability than they have today?
- What new roles might be considered for a radically different submarine and what might their characteristics be to effect this paradigm shift?
- What are the technology improvement barriers that need to be overcome for very significant improvement of the ideal submarine force mix or radically different submarines?

The Task Force's terms of reference provided the analytical framework which guided the study and deliberations.

While the terms of reference emphasize the next few decades, the Task Force has noted that today's design decisions will impact the next 50 years.

BRIEFINGS

Government

Bettis Atomic Power Laboratory
Central Intelligence Agency
COMSUBDEVRON 12
COMSUBLANT
Congressional Research Service
DARPA
Defense Intelligence Agency
Joint Staff, J-8
Knolls Atomic Power Laboratory
NAVSEA 08-Naval Reactors
NAVSEA PMS 404
Naval Surface Warfare Center
Office of Naval Intelligence
Office of Naval Research
OPNAV Staff
- N091
- N23
- N6
- N81
- N87

PEO SUB (Seawolf, NSSN, Sub R&D)
USCINCSOC, J-7

Commercial and Non-Government

Center for Strategic and Budgetary Assessments
Draper Laboratory
Electric Boat Company
Newport News Shipbuilding
SAIC

Other

Mr. Anthony Battista
Mr. Gerry Cann
Dr. Johnny Foster
Dr. Andrew Krepinevich, National Defense Panel
ADM William Owens, USN (Ret)
Dr. Michael Pillsbury
Mr. Norman Polmar
CDR Jonathan Powis, RN, British Embassy
Dr. Lowell Wood

In addition to receiving fifty briefings, the Task Force spent a day aboard *Seawolf* and visited the Electric Boat facility at Groton, Bettis Atomic Power Laboratory at Pittsburgh, and Knolls Atomic Power Laboratory at Schenectady. Verbal and written inputs were also received from CINC Pacific Command, CINC Central Command, CINC Strategic Command, CINC US Forces Korea, CINC US Pacific Fleet, and Commander Fifth Fleet.

OBSERVATIONS

BIG PICTURE MILITARY TRENDS

- Multiple, simultaneous, changing geographic foci
  - Regional crises will require wide range of capabilities
- More stealth, agility, and self-defense required
- Commercial technology, available to all, driving information dominance
- Proliferation of technology in sensing, guidance, and targeting significantly increases weapons effectiveness
- Separation of ID and shooter
  - Precision strike
  - Much smaller forces
- Diversity of missions - increases potential for dangerous asymmetries
- Availability of technology/info reduces decision cycle time, reduces warning time, and increases need for rapid response capabilities

First, the US has moved, is moving, and will continue to move away from a single, dominant geographic threat focus. The United States will be faced with multiple, simultaneous, dynamic, and dangerous regions of interest.

Second, our deployed forces will be at risk of surprise attack from sources with surprising capabilities. These forces must be much more self reliant and have robust defenses. Stealth, agility, and self-defense will be critical.

Third, continued development of information technology will make available to all countries the capability to find, target, and strike adversaries with precision from long range with destructive effect. This will put our air, land, and surface sea forces increasingly at risk.

Fourth, these evolutions will separate the detection of targets from the shooter, allowing precision strikes from great distances with smaller forces. The speed and flexibility of connections between the shooter and the detector will become the determining factor in the engagement.

Fifth, the Navy's role in these diverse missions will find it operating close to and across the enemy's shoreline. Potential asymmetries, such as those attributed to mines, conventionally powered submarines, and anti-ship cruise missiles, challenge the Navy's ability to operate in this littoral environment.

Finally, the time window for military responses will compress at both the tactical and strategic level. Future adversaries will not allow the United States months to transport forces, establish a logistic train, prepare, and attack. Similarly, future adversaries will likely emphasize mobility and deception in battle to increase their survivability, suggesting the need for quick responses to fleeting intelligence and targeting information.

WORLD FROM DOD PERSPECTIVE

in the next 10-20, then 50 years

- 10-20 years in the future
  - No plausible strategic competitor
    - increasing number and locations of regional threats
  - Current platforms still exist, but effective kills per unit have increased
  - Regional conflicts closing exchange ratio from "1000:1" in Gulf
    - Advanced technology available to all
    - Higher casualties
  - Weaker alliances
    - Shorter lived
    - More tenuous
    - Fewer overseas bases and more restriction on use
- Later - up to 50 years
  - Plan on at least one strategic competitor
    - Russian technology, nucs & equipment, industry
    - China uses economic & military muscle to become more aggressive
  - Decisions now will impact on capabilities then
  - Plan on
    - Technology diffusion accelerating
    - Recurring regional crises

Current DoD programs appear to match the consensus vision of the environment over the next 15 to 20 years: no superpower rival, US involvement in multiple locations, and current platforms will be sufficient because their effectiveness will be increased.

There is also agreement in recognizing that the exchange ratio of 100:1 that we gained in the Gulf War is unlikely to be repeated due to the diffusion of technology and the expected strategy of seeking to maximize US casualties in the hope that we will leave. There will be weaker alliances that will be more temporal in nature and will have more restrictions on the use of overseas bases.

On the other hand, the Task Force is concerned about extrapolating these programs and plans into the latter part of the 50 year period. It is obvious that the decisions we are making now will impact on that time period. We are particularly concerned that the technology diffusion will accelerate and that the subsequent threat to our forces will increase significantly. We believe it is prudent to expect a strategic competitor in the timeframe which will make recurring regional crisis much more dangerous and unpredictable.

DOD ISSUES

- DoD must expect in both time frames
  - Ability to influence peacetime situation
  - Area of action will be closer to "enemy" than to home
  - Protect freedom of sea/air commerce
  - Vulnerable to casualties from small threats
  - Global information collection/dissemination

- Deterrence, presence, and reassurance requirements will continue
  - Need ability to impose will with fewer resources

Despite diminishing resources, DoD will continue to be expected to maintain deterrence and global presence, support our allies, and protect our vital interests from adversaries.

Future challenges to realizing these expectations include 1.) the increased dependence on expeditionary warfare, 2.) the attendant need to collect and interpret information on a global scale, and 3.) increased vulnerability to casualties from small weapons.

NAVY ROLE

- Strategic Deterrence -SSBNs
  - Possible fewer warheads/boat
  - Re-use extra platforms for off-shore firepower
- Protection of sea lanes and sea lift
- Presence/crisis response
- Global information collection
- Stand off force and defense projection
  - Air power
  - Conventional missiles (cruise or ballistic)
  - Theater missile defense (TMD)/Air Defense
- Littoral sea control and power projection ashore
  - Logistics and ground force projection
  - Mining and mine countermeasures
  - Anti submarine warfare (ASW)
  - Self Protection - Air/TMD/ASUW
  - Disruption of shore infrastructure

Ballistic missile submarines (SSBNs) will continue to be a key member of the strategic triad. (Under various options of treaties still being developed, the number of warheads per boat may shrink.) SSBNs removed from their nuclear strategic missions by the same treaties can be converted to deliver conventional missiles, thus augmenting the land attack/strike capabilities of the Navy.

The traditional Navy role of sea control and defense of commerce will continue. In the course of peacekeeping, there will remain a requirement for forward presence and for a manifest ability to take the war to the enemy. The Navy's ability to collect information while in these roles remains a high priority.

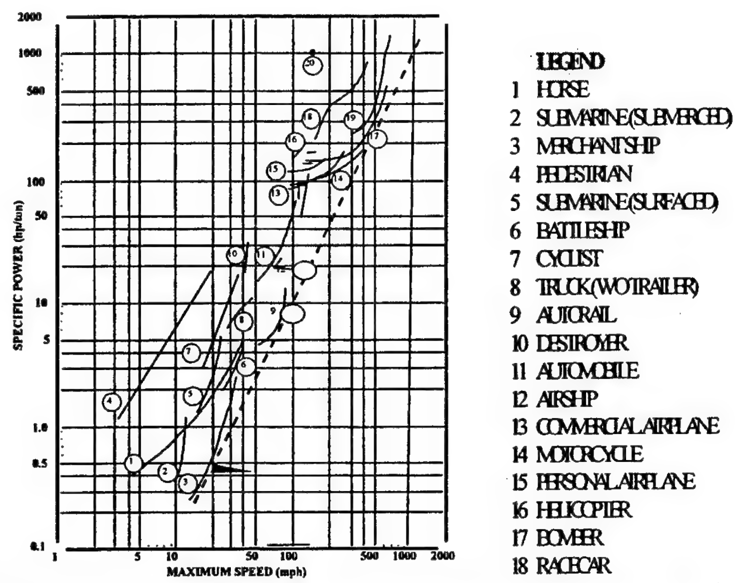
Although "blue water" missions can't be ignored, the sea-land (littoral) interface will become more important. Projecting force to the land and protecting the land from forces, whether aircraft, missiles, or long range munitions, are both required.

Finally, littoral sea control and self protection must be maintained in the potential presence of undersea threats (enemy mines and submarines), surface threats, aircraft, and missiles. Amphibious operations and continuing land strike in support of troops on the ground will also remain as requirements.

WILL THESE NAVY ROLES ENDURE?

- We did not examine Navy-wide force mix in future scenarios
- We expect the Navy roles to endure
  - Inventory, inertia, and tradition
  - Operations independent of basing
  - Enduring covertness
  - Heavy lift will always be by sea

GABRIELLI AND VON KARMAN



The most celebrated work in the area of lift-to-drag ratios is an article by von Karman and an ex-student of his named Gabrielli, published in the late fifties. Their centerpiece is a plot illustrated above. The right-hand bounding line has since been exceeded slightly by super-tankers and by their aircraft equivalents like the 747.

This graph shows that sea power (curves 2, 3, 5, 6, and 10) are the most cost-effective, in terms of horsepower per ton, of delivering a payload, such as ordnance or unmanned vehicles, to a distant location. The illustration supports the Task Force's assertion that Navy roles will endure.

WHAT IS THE NAVY DOING ABOUT THIS?

- On-going force structure trends
  - Logistics ↑
  - CVN →
  - SSN ⇩⇩
  - Surface combatants ↓
  - Amphib. ↓
  - Air wing ↓
  - SSBN ↓

- Redistribution of missions
  - TMD - Aegis
  - Fire support
  - De-emphasis on ASW
  - Increasing jointness and connectivity and synergy
- Reduced R&D
- Planned procurement will not provide for even the reduced force levels projected

Because of the changing national security environment, there is an ongoing reduction in the number of platforms in the fleet, a redistribution of missions, and reductions in R&D and procurement. For instance, the move away from the Cold War Soviet threat has caused ASW to be de-emphasized, almost completely in surface and air activities.

The Task Force notes that the SSN fleet is experiencing proportionally the greatest reduction in overall strength.

The Task Force believes that force structure priorities must be reviewed because they are inconsistent with the trends we perceive.

ATTRIBUTES OF AN SSN

- "Unique"
  - Stealthy
    - Acoustic & non-acoustic
    - At all speeds
    - Open ocean & littoral
  - High endurance
  - Mobile
- "Pretty Special"
  - Cost up front vs. O&M
    - Complex integrated system
  - Heavy weapons against surface combatants
  - Covert Intelligence
  - Covert weapons ⇒ surprise
  - Reduced number of personnel at risk vs. other platforms
- Matches Navy Roles
  - Sea control
  - Covert intelligence gathering
  - Crisis response
  - Covert strike
  - Protection of off-shore forces
    - ASW
    - Anti-mine
    - Covert special strike
    - ASUW
    - Blockade/barrier
  - Presence

Our review identified some attributes of attack submarines that are unique to that platform and some others, which, though not unique, are "pretty special. " These traits enable SSNs to be key participants in the execution of several Navy roles.

Stealth is the *sine qua non* submarine attribute. The US has paid a lot of attention to acoustic stealth over the years, and we are improving in our ability to reduce non-acoustic signatures as well. While our submarines have become increasingly more stealthy in all environments and at all speeds, their advantage has eroded due to technological improvements of our potential adversaries' systems --particularly in asymmetric threats like diesel submarines operating at low speeds. Abundant energy available from nuclear reactors enables sustained high speed and endurance at any speed, with the added benefit of being free from logistics considerations.

There are other attributes that the SSN shares with other platforms, though not all with a single platform, therefore the combination is unique. The total life-cycle cost of an SSN is dominated by its construction; O&M is relatively small. This factor inhibits building SSNs in sufficient numbers, but allows them to be used extensively as an integrated weapon system. Their heavy torpedoes are excellent weapons against surface ships. Because they are stealthy, they are excellent platforms for intelligence gathering and surprise weapon launch when the enemy is unaware. This covertness allows detection of more data because the target is not as cautious as when aircraft or satellites are known to be in view. The effectiveness of surprise weapon strikes can be greater than normal because they attack targets which are not at heightened alert.

While it is often stated that visual presence is a major attribute of surface combatants, the effect on a potential adversary of thinking an SSN is in his area can be very important as well by causing him to curtail transport activities and to change the deployment of his sea forces to more protected locations. Such "presence through uncertainty" is a valuable attribute.

SSN ATTRIBUTES VS. MILITARY BIG PICTURE

- Stealth, endurance, and mobility are increasingly relevant
  - SSN relatively immune to improvements in information and weapons technology
  - Provides "first on scene" capability covertly if required
- Already flexible but needs to be even more so
- Littoral environment requires more flexible payload, defense and operational modes
- Firing from an initially covert position greatly complements precision strike
- A large technological edge special for the US
- Available to do missions that others have de-emphasized

Technology advances and proliferation will make the submarine's stealth, endurance, and mobility even more important attributes in the future as surface and air forces become more vulnerable. An SSN's initially covert position allows surprise strikes, and its stealthy mobility provides the opportunity to regain a new covert firing point and repeat the process (though without the surprise factor).

This flexibility is currently limited by the amount and types of weapons carried and the inability to communicate without giving up stealth. Both can be improved to take better advantage of the effectiveness of precision weapons for land-attack.

As other platforms, pressed by new missions and new threat technology, have de-emphasized some missions, the submarine has been available to expand in those mission areas, e.g., ASW.

SOME INTERESTING DECISION DIFFICULTIES

- Fewer SSNs, more places to be, increased tasking, and less deployed support
- Stealth vs. connectivity and time synchronization
- High tech Russian/ice/blue water vs. littoral
- Shrinking industrial base vs. need for capability to stay "the best"
- Budget decisions not matched to assumptions leads to "average," not minimum regret
- A unique industrial base with no commercial analog may be forced to live from hand-to-mouth for an undetermined future

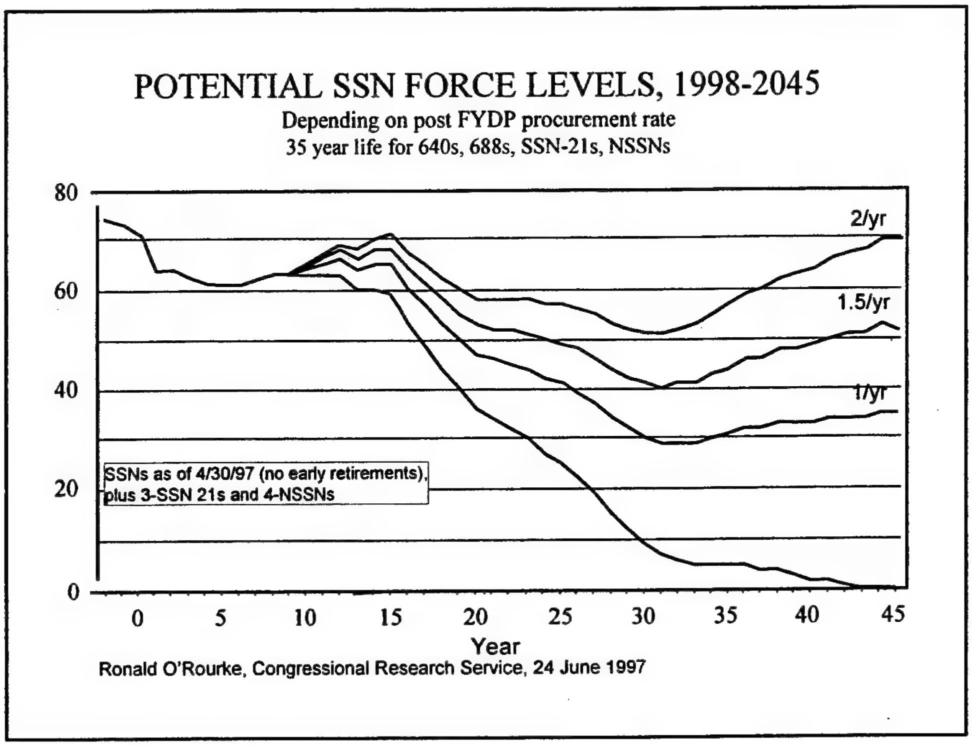
It is recommended that effort be invested in emphasizing to the design community the centrality of stealth to the submarine and to the fact that stealth is inevitably placed at some degree of risk by simply being in foreign littoral waters, especially, by whatever releases of energy are needed to execute the mission, such as communication transmissions or ordnance launching. It is also noted that our experience in coastal waters is limited and we need information about, for instance, acoustic transmission phenomena, bottom topographies, and current fields.

It is important to note that these dilemmas can cause "budget"-driven decisions to ignore the serious dangers of choosing "average" paths. If, as we believe, SSNs will not just be useful, but crucial in several future scenarios, not dealing with these difficulties now will lead to major failures in our national security at precisely that time when we have limited alternatives. DoD planning must emphasize getting to the least worst outcome in future scenarios, because averages do not apply to single events. SSNs are particularly useful in avoiding the "worst" outcomes.

WE ARE BUILDING TOO FEW SSNS

- QDR and Joint Staff reviews of force structure have concluded 50 to 70 SSNs are required
  - Without overbuilding inventory we will have at most 40 during critical periods
  - These reviews do not anticipate a strategic competitor in these periods.
- Current threats allow all forces to be effective
- Diffusion of high technology will increase the threat to forces in different ways
- Sensing and localization at and above the surface and precision long range weapons will put surface/air forces at risk in the 20-50 year time frame
- Decisions are being made using current threat/force combinations, not future trends

The decision concerning proper SSN construction rate should be reevaluated. It is understandable that when current forces are very effective, continuation of plans to use them into the future is normal. However, the Task Force believes the threat trends discussed previously will reduce the effectiveness of surface ships significantly within 30 years, while leaving the SSN relatively immune to threat escalation. This dynamic change argues that we should have more, non-vulnerable platforms available in the second quarter of the next century, and therefore we should accelerate SSN construction to a rate capable of sustaining current force levels.



This graph shows projected SSN force levels resulting from various NSSN build rates and assuming a 35 year ship life. The 35 year life assumption is optimistic, since its replacement of the current 30 year SSN life is not currently planned by NAVSEA.

However, the graph shows that even under this optimistic scenario, SSN force level will dip below the QDR level of 50 unless a NSSN build rate of 2 per year or greater is achieved. At the current ship life of 30 years, the dip effect is even more pronounced.

Moreover, 35 year ship life may be impractical for all older classes because of limited reactor core life and need to refuel late in the ship's life.

NSSN IS A MAJOR STEP TO THE SUBMARINE OF THE FUTURE

- Uses technology to enhance affordability
  - Simpler power plant
  - Modularity
    - Construction - Design - Plugs
- Production work force is down by a factor of ten at Electric Boat -- lower overhead rates
- Increased flexibility for introducing/changing electronics
- Stealth equal to or better than Seawolf
- Advanced Swimmer Delivery System (ASDS) interface
- Non-penetrating masts
- Re-configurable torpedo room
- Larger lock-out/off-loading chamber

We found the New SSN (NSSN) to be a significant enabler for future growth and exploitation of future technological advances. It uses technology to enhance not just performance, but also life cycle affordability via major system and component simplifications and a balanced design/capability approach. For example:

- It incorporates a simple and very efficient nuclear propulsion plant.
- The modular design allows modules to be constructed and tested off-hull, then inserted as independent units, without requiring special interfaces between them.
- The design also offers the possibility of clean transverse cuts of the hull which permits the design and installation of mission specific plugs during construction. These features, plus the reduction of manpower at the ship yards, have allowed technology insertion to save cost.
- The combat system has been designed using mostly commercial off-the-shelf (COTS) equipment in an open architecture to accommodate technology insertion (even prior to delivery) to ensure the ability to track electronics technology growth throughout the life of the submarine.
- The performance of the NSSN compared to Seawolf is favorable except for <u>maximum</u> speed. However, NSSN is expected to have a greater <u>tactical</u> speed before either sensor blinding or self noise become limiting factors. It also has some design features which make it more flexible in operations near land.

THE NSSN SHOULD CONTINUE AND EVOLVE

- The previously noted prospective inventory shortfall needs to be corrected
- The NSSN provides an effective basis for further evolution
  - Pay particular attention to the sensors and payload
- We should not stop an effective program until we have a superior replacement
- We need to get comfortable with the "flexible interface with the water," and we need to design and test it
- The "strategic pause" allows us this option

The Task Force was not asked about the NSSN, but since we make suggestions for a significant change in future SSNs, we also must note that we do not suggest the NSSN program to be stopped while waiting for such changes. We need more SSNs, the NSSN is ready to be built, and it represents a platform which can evolve significantly toward our goals for future SSNs. NSSN has a first-rate propulsion system and the ship can be modified using inserted sections to improve the interface with the water using more flexible techniques than torpedo tubes and vertical launch systems (VLS). Improvements in the sensor system can also be evolved quickly.

WE PROPOSE THAT THERE BE A TRANSITION TO THE NEXT SSN AVAILABLE IN THE 2020s

- NSSN continues and evolves until then
- The next generation SSN must be a highly capable warship with rapid response capability
  - It should have flexible payload interfaces with the water, not torpedo tubes, VLS and other special purpose interfaces
  - It should not constrain the shape and size of weapons, auxiliary vehicles, and other payloads when they are used
  - It is not only a large mother ship
- It will operate in "open ocean," littoral, and land attack modes

The Task Force suggests the follow-on to the NSSN be available in the 2020 time frame and that it be very different from the NSSN as currently designed. In particular, it should not have torpedo tubes, VLS tubes, or other weapon specific interfaces with the water. It should have a flexible interface which does not constrain the shape and size of weapons, auxiliary vehicles, and other payloads when they are used. We suggest using "bomb bay" techniques or other large aperture openings, coupled with external storage of rapid-response weapons.

SSN FORCE MIX

- We recommend that the successor to NSSN be "large" nuclear ship because
  - We need to cover the world from the US => high transit speed, independent logistics, and endurance
  - We need to have flexible payloads=> large submarine size (10-12 meters diameter)
- The NSSN and future SSNs must have adjuvant systems recognized as SSN payload instead of being a substitute or extra class of ship
- Diesels (and other non-nuclear subs) appear to be best characterized as local area warships (smart mine fields) with an enhanced weapons effect range and sensors
- Can't move much =>stay in critical pathways
  - Deliver weapons effectively

The Task Force examined the possibility of providing more effective submarine forces using smaller or non-nuclear ships, and firmly reaffirmed that "large" nuclear platforms are the preferred choice. At expected force levels, the concept of a high-low mix is unpersuasive. This picture is dominated by the requirement to deploy ships far from home bases and in widely separated areas of the world, making speed and endurance very important. Large size is also required because independent operations far from bases requires significant payload volume to support multiple missions.

The Task Force also recognized that operations close to enemy shores will require using adjuvant vehicles for various missions, especially in shallower water. We foresee significant missions in surveillance, reconnaissance, mine-removal, people delivery, and others for such vehicles used as a part of the overall capability of the SSN. While considering use of other vehicles independent of the SSN, we rejected that path because the coordination requirements will necessitate very close control by the SSN in any case.

Diesel and other conventional propulsion ships can not move as effectively as nuclear ships. Staying virtually still, diesel submarines are useful for nations to block critical, near-shore areas, because their sensors and weapons are effective over a larger range than mines. But the US requirements involve going to these critical areas, not protecting approaches to the United States.

SSN FORCE MIX (2)

- British compared fewer nucs with more diesels for “200 mile range” operations and chose nucs
- The rest of the world will note these advantages of diesel subs for operations near their shores and we will confront situations which will have these platforms as our opponents. They will be good at what they do. They may be supplemented and/or replaced by off-shore deployed sensors with land-based attack capability.
- Just because we choose not to build diesels, we must learn from the development of such ships for
  - Technology infusion
  - Threat understanding
  - Operational development
  - Training and tactics for close range engagements

The British Navy made the same choice - nuclear propulsion - even when the mission was assumed to be within 200 miles of home.

Coastal defense is the niche claimed for short-legged conventionally-powered submarines -- the impetus for submarine development resided for a long time in France where it was hoped to be a cost-effective means of holding the British fleet at bay. (In the modern era a better alternative for a small country might be the use of sensor fields on the sea floor and land-based missiles instead of diesel submarines.) Ships require maintenance, and their crews require training and practice, and these factors have been found to mandate a fleet of at least six or so ships, to maintain proficiency for one or two deployed units.

However, there is an active market for diesel submarines in the world, and we must expect to contend with them. Therefore, we should recognize that threat and develop technologies for close-range engagements which will be very likely when we “stumble” into the vicinity of a “stationary” submarine.

ELECTRIC DRIVE

- The US has a significant advantage in SSN performance because we have overcome the constraints of the current mechanical propulsion system. However, future progress will be difficult.
- Electric drive potentially allows
  - Significant geometric design flexibility, especially with "integrated stern"
  - Increased torque for lower RPM
  - Better distribution of power to ship and payload and special propulsion
  - Sharing of technology of power conditioning, control and distribution
  - Use of "direct conversion" reactor
- We expect SSNs in 2040 may use electric drive, but we recommend NSSN and its immediate successor use evolutions of the current propulsion and concentrate development on the non-propulsion part of the ship and its payload.
- However, if electric drive is available from other programs, earlier insertion could be considered.

At present, our submarines have three kinds of internal energy distribution systems; mechanical, electrical, and hydraulic. Mechanical is used for and only for propulsion, hydraulic is being superseded by electrical, and electrical already does all the rest. It is argued that an all-electric ship would permit a flexible assignment of energy; the very large quantity now fenced off for propulsion and unavailable elsewhere could, at low ship speeds, be used, for instance, in weapons launch, or making fuel for adjuvant submersibles. In fact, a fully all-electric ship would use a "direct conversion" reactor, removing the requirements for turbines and other power plant machinery.

Even though the Task Force recognized the positive aspects of this argument, we recommend that the next generation SSN not include electric drive. We believe the resources required for such a change should be used to deploy a much more effective "front-half" of the ship and that there are not sufficient resources within the submarine community to do both effectively.

USE OF A LIMITED NUMBER OF PLATFORMS MUST BE IMPROVED

- Ratio of fleet to "on-station" positions (K factor) is ~5
- Decreasing (i.e., improving) this ratio increases the margin the country has in use of these assets for global presence
- The next generation SSN design requirements should include actions to improve this factor
- To improve this ratio, we should consider
  - A longer life platform
  - Less maintenance down time
  - Off-platform training efficiency - simulation
  - Automation
  - Connectivity to allow remote expertise for special tasks
  - Logistics improvements
  - Innovative manning/crew rotation
  - Forward staging of critical support
  - Ability to rearm/resupply forward

If, as we expect will be the case, the demands placed on submarines are going to increase because of the increased need for their stealthiness, then the US will run into a numbers problem no matter how many SSNs we produce. Increasing the time on station of each ship will be important, not so much to reduce budget pressure by reducing the numbers of SSNs, but rather to increase global presence of the submarine force in emergencies with so few total platforms. We believe that improvements can lead to nearly continuous deployment of the hulls, with crew rotations taking place in forward areas. That eventuality has to be incorporated in today's design practices -- reduced maintenance needs, reduced crew size, novel logistics support, automation/simulation, and especially a flexible ordnance loadout to adapt easily to a variety of missions. For instance, more automated shipboard equipment with effective shore-based simulators, may reduce the need for extensive at-sea time between deployments in order to maintain crew proficiency, thereby possibly improving the K factor.

Existing personnel policy regarding personnel operating tempo also drive K factor. Improvements in this area, perhaps through innovative crew rotation, coupled with an SSN designed from the start with these improvements in mind, would result in increasing the availability of SSN assets. The Task Force is aware that any increased use of current SSNs, designed for a single crew under current personnel, training, and operational policies leading to a 30 year ship and propulsion plant life, will result in faster fuel consumption and shorter life and exacerbate inventory shortfalls.

THE CURRENT DOD PROCESS IS NOT LIKELY TO MEET THE CHALLENGES

- Non - integrated decisions
  - Point solutions
- Too many small "pet ideas," too little integrated implementation
- Everybody "works" on "the program"
- Insufficient outreach to all of industry
- DoD should concentrate on defining requirements and measuring performance
  - Contractors concentrate on solutions and delivery

The DoD process in general, and the SSN acquisition decision process in particular, is unlikely to meet the challenges our recommendations will present. Within a closed community, even if vigorous debate precedes a consensus, there cannot be sufficient dynamics over the long run. Such a systems relies on the personal capability, maturity, and judgement of individuals to accept criticism of their ideas. It is a tribute to the quality of the leadership of the "silent service" that the system produces such fine equipment and people, but the Task Force believes that the requirements for change imply that the process must become more open, more dynamic.

CONCENTRATION ON THE NEXT SSN SHOULD BE ON THE FRONT END OF THE SHIP

- The Navy should concentrate near-term efforts to develop concepts for the platform and weapon delivery designs
- A program should be developed to define innovative payloads
  - Sensors
  - Torpedoes
  - Missiles
  - Mines
  - Adjuvant vehicles
  - ...and the defense against such weapons
- DARPA must collaborate with the Navy on this innovative effort--potentially via ACTDs/ATDs.

The submarine will have to shoulder a wider responsibility than that of a torpedo boat, and to enable that, our key recommendation is that the torpedo room be exorcised and the ship's front-end be rearranged to create an open (free-flooding) space patterned after a cargo hold or, more aptly, a bomb bay. That will remove the design constraints of 25 inch hatches and 21 inch ejection tubes and, thus, widen the availability to the submarine community of the innovative abilities of US industry, whose help will be needed in developing ordnance to handle, for instance, land attack.

We believe that this "bomb bay" innovation should be part of a redesign of the entire front end that should include considering:

- eliminating the sail (and thus gaining speed and agility at shallow depth at high sea state and reducing radiated- and self-noise)
- replacing the sonar sensors with an integrated system having much improved performance.

The Task Force is not unmindful of the difficulties that lie in the path of such an endeavor and urge that DARPA and the Navy collaborate on it in order to best marshal a wide participation by US industry. It is specifically suggested that DARPA take on the development of novel payloads -- low-cost, artillery-size precision guided munitions (PGM), adjuvant vehicles to extend mission performance in inshore waters, stealthy means of launch, sensors, and other creative ways to use the increased flexibility of the new platform design led by the Navy.

MAINTAINING SUPERIORITY

- Since the SSN represents a case of significant technological superiority in favor of the US, care must be taken to prevent that superiority eroding because of too "collegial" a process versus one with constructive adversarial relationships.
- We must greatly strengthen the competition of ideas integrated into the SSN program.
- We believe that government internal resources should shift their focus from telling industry how to build things towards developing techniques to measure performance in realistic ways.

Since the SSN represents a unique "crown jewel" for the US, we are the only ones who can challenge whether they are the best they can be. If we are the best, then only we can measure performance well enough to see where improvements can be made. Because even for SSNs the diffusion of technology to other nations will cause our advantage to shrink in time, particularly against non-air breathing conventional submarines and emplaced sensors; we need to measure overall performance and detect the flaws and elements in order to fix them. We can no longer rely on measuring average performance every so often.

Building a constructive adversarial relationship between the contractors and the government would increase the competition of ideas in the program. The government should focus on measuring the performance of what is delivered by industry, while industry should creatively develop alternative methods of meeting requirements. Such increased competition of ideas will improve the performance of both the products and the acquisition process. These same measurement techniques can be used later in the SSN life to detect erosion in performance.

MAINTAINING SUPERIORITY (2)

- Progress in this area will be measured by more innovation in the acquired SSNs and better measurements of their performance before acceptance.
- The technologies developed to measure performance more realistically will allow "self-test" and correction to be much more effective.

RECOMMENDATIONS

- The NSSN should continue and evolve, leading to a next generation submarine in year 2020:
  - Large nuclear submarine
  - About same propulsion plant as NSSN
  - Flexible weapon interface with the water
- For existing submarines, K factor improvement will help global presence requirements during inventory shortfalls, but will limit life
  - Improve operational techniques to improve K factor for use during periods requiring increased global presence with existing SSNs. Use of these techniques will exacerbate the inventory problem in the long term.
  - Include in the next generation SSN an improved K factor with potential extensions of SSN life that are possible without change to the back end.
- Wide open look at future submarine by DARPA/Navy
  - Navy execute on development of platform
  - Maximum industrial input
  - Maximize performance measurement techniques by government creates intellectual competition of ideas

The Task Force offers three recommendations. First, the NSSN appears to be a successful program and should be allowed to continue and evolve. The next generation SSN after NSSN should reflect improvements in the "front end," e.g., flexible interface with the water, and feature about the same propulsion plant as NSSN. Second, the Navy should examine ways to get more use out of SSNs, through K factor improvement. Such improvements should be consistent with the Task Force's emphasis on the "front end" of the ship. Ongoing, incremental design improvements in the existing NSSN propulsion plant, combined with "front end" improvements suggested for the next generation SSN, may result in an improved K factor without detriment to the planned 30 year ship and propulsion plant lifetime. Lastly, DARPA and Navy must engage in a cooperative effort to develop new payloads, encourage wider industry participation, and create new performance measurement techniques.

OTHER OBSERVATIONS ON ATTRIBUTES OF SSNs

ELECTRIC DRIVE

- Current propulsion train constrains SSNs
  - Very long dimensions
  - Extreme tolerance constraint
    - 10^{-3} inches @ 100 feet of propulsion train
  - Quieting of multiple sources coupled via this train
  - Torque limits minimum RPM
  - Constrains volume usage
  - Progress requires breakthroughs in mechanical/thermal areas => special technology

Electric drive propulsion systems have already become common in large cruise ships because they permit better arrangements within the ship, leading to more revenue-producing space. Counterpart rearrangement advantages exist for warships generally, including, of course, submarines. For the submarine there is the additional great concern about stealth; the energy that is radiated acoustically comes dominantly from the propulsion system, at least at high speeds, and strenuous efforts are made to minimize it. Those efforts have been extraordinarily successful, but their realization requires machinery parameters (size, weight, and precision) that are at or near the limits of what can be achieved. It is argued that electric motors will permit a substantial advance in radiated noise control, circumventing the present-day mechanical limitations.

DIRECT CONVERSION

- Direct conversion of heat to electricity removes the turbines and steam from the propulsion plant and allows greatly increased internal design flexibility with quieter operations
- The Panel is impressed with the youth, competence, approach and enthusiasm of the teams working on the problem of direct conversion from the reactor heat to electricity
- Practical application of this technology may require decades, so do not lose faith -- keep it going
- The goal of this program should be to enter the SSN fleet at the earliest in the generation after the follow-on to the NSSN. Heroic efforts should not be used to try to achieve this goal.

EFFECTIVE CONNECTIVITY NEEDS TO BE EMPHASIZED

- SSN stealth is of paramount importance
- A bell-ringer to alert an SSN to decrease stealth for connectivity on demand is vital.
  - For constrained cases, e.g. task forces, can we provide more effective bell-ringers using acoustics or other means
- An internet-like protocol-based "asynchronous" information transfer system (10^6 bits per second (BPS)) will allow SSNs to support their missions -- while maintaining stealth
  - Assumes SSN decides time delay between transfers
  - Requires others to be "tolerant"

The Task Force concurs that the new missions anticipated for SSNs will require much more connectivity with other forces. However, because stealth is so important, we believe sufficient connectivity should be the goal, not connectivity as good as other ships. In particular, exposing antennas to be a part of a "morning" video teleconference should not be considered. The ship should adapt its connectivity posture to complete assigned missions with minimum compromise of its stealth. Therefore, in cases where an external authority requires change in connectivity status, that authority must have a bell-ringer capability available to tell the ships to change its posture. Alternative solutions to the existing ELF system should be explored, including localized systems for use within a task force, such as acoustic systems.

The use of "asynchronous" internet based systems for delivering targeting coordinates and battle plans are perfect for SSN operations. These systems are evolving for everybody, and they allow any subscriber to ask for data when it wants to, not when a sender wants to transmit. Some missions, such as real-time adaptive air/missile defense, don't work in this environment, but the SSN does not contribute well in such cases anyway.

EFFECTIVE CONNECTIVITY NEEDS TO BE EMPHASIZED (2)

- We believe that developments described to us to provide stealthy - larger aperture, multi-band antennas which provide 10^6 order of data rate BPS need to succeed, and are much more important than working on 10^7 - 10^9 order data rate systems.

- We believe acoustic link R&D for very long range (10^6 m) or network applications, should accelerate

The Task Force believes that successful completion of the deployment of present programs to provide about a MBPS are required, but we question the utility of pushing to greater bandwidths soon.

ACTIVE VS PASSIVE ACOUSTICS

- Improved acoustic quieting alone is not sufficient for dominance, parity should be the expected case
  - Detection ranges will be very short - however improving sensors is important
  - We currently are among the best at reducing radiated acoustic noise
  - Technology of both sensing and quieting is being deployed by others
- We must assure that we are not "less than the best"
  - Measure ship performance more often in more realistic ways
  - Closed-loop detection-correction should become the norm
  - Know how well sensors operate

Historically US Navy submarines have been able to rely on an edge in acoustic quieting. This advantage is declining and we must plan for parity in acoustic quieting - not continued superiority.

Passive detection ranges are becoming ever shorter, but this dictates that we must not flag in efforts to improve sensors and strive for some level of advantage. Although we continue to be among the best, if not the best in acoustic quieting, others are deploying the required technology and are closing the gap, particularly in asymmetric situations, such as diesel versus nuclear SSNs.

We must assure that we never become less than the best. In order to maintain that level of performance, it is imperative that we measure our submarine acoustic performance in the most realistic ways possible. Techniques need to be developed that enable us to carry out closed loop detection and correction in the course of normal operations so that we can continually tweak our own submarine performance. This "tweaking" must include onboard assessment of how well our sensors are performing versus the expected performance.

ACTIVE VS PASSIVE ACOUSTICS (2)

- Others have always planned that they will be detected first
  - We need to plan for this to happen to us sometimes
    - Fast reaction, short range response
    - Countermeasures
    - Use of active by us and confusing them
    - Weapons
      - Point defense
      - Short range
      - Shallow water

In the past our adversaries have had to plan for being detected first. Consequently they have been forced to consider and develop strategy and tactics to respond to this occurrence.

We must confront the same possibility and this situation dictates that we develop the capability for fast reaction and short range response including the use of countermeasures and active techniques to confuse the enemy.

Weapons, too, need reconsideration. It would be most desirable to have a point defense capability that could operate effectively at short range and in shallow water. Other techniques adapted to short range and shallow water operations should also be considered and developed.

NON-ACOUSTIC SIGNATURE CONTROL

- Shallow depth operations will provide significant non-acoustic signatures to enemies:
  - Masts out of water
  - LIDAR detection
  - Low search rate sensors are effective in confined areas
  - Magnetics
  - Hydrodynamic effects
  - Biological
  - Electromagnetic

The confined operating space of the littoral enhances the threat that relatively unsophisticated detection devices coupled with elementary sensor-to-command-to-prosecutor systems could exploit the SSN's signatures and relative inability to maneuver as freely as it might otherwise in open waters. Consideration therefore should be given to the development of signature control measures other than acoustics.

Continuing emphasis by the Submarine security program to determine potential signatures that could compromise the submarine is also very important to maintain our capability against sophisticated enemies. Moving to more closed loop signature control will be enhanced as the government develops better capability to measure performance.

If the SSN's role includes "vanguard" operations as a prelude to a naval operational maneuver from the sea or strike operations to support the joint force commander, requirements may dictate near-surface tactical maneuvering. To provide for the most effective survivability, such approaches as reduced IR/RF masts, reduced wake, and LPI communications could loom important.

MANEUVERABILITY/HYDRODYNAMIC CONTROL AUTHORITY

- Shallow and constrained water operations requires that greater emphasis be placed on maneuverability and control authority, especially at low speeds
- Auxiliary active maneuvering devices and innovative control surface design will be required
- Increased adaptability to environment, e.g. bottoming, use of terrain masking

Operations in the littoral demand that the SSN be able to operate effectively close to the land mass or in bodies of water that are enclosed and shallow. With the SSN close to the bottom there is a greater need for control to prevent groundings or damage from obstructions (such as wrecks or other hazards to navigation). Also the event could cause a transient noise signature which could possible be detected by either shore based sensors or diesel submarines in the vicinity. Therefore, the ability to maneuver both in depth and heading is needed to ensure that the position of submarine is accurately maintained.

At very low speeds the present day control surfaces would be only minimally effective. The need, therefore, exists for some form of active auxiliary system for low speed maneuvering and/or new designed control devices or surfaces.

In the future the SSN might not be able to avoid detection simply by its stealth but must also take advantage of the environmental conditions such as bottom terrain. This fact could require the SSN to replicate its surroundings if ensonified by an active sensor.

HYDRODYNAMICS

- NSSN hull penetration with fiber is a good start towards modifying sail height or "removing" it. This is consistent with a goal of symmetric flow.
- We believe more volume will be required, therefore length/diameter relationship allows fatter hulls with slight performance improvement relative to NSSN.
- Shallow operations require more attention be paid to hydrodynamic signature control
- Propulsor evolution needs to continue.

The sail is a major contributor to the sonar self-noise, to the radiated noise acoustic signature, and adds greatly to the overall drag of the submarine hull. The new fiber optic periscope is a good start by allowing for a reduced size sail. Going the next step to a very small or no sail at all should be the goal of any future design.

If additional volume is required for future designs then a submarine shape that is larger in diameter (fatter) could be used with only a slight increase in drag.

The operations of the submarine in shallow water puts even more pressure on the requirement for improved stealth including the hydrodynamic components. Therefore, research needs to continue in hydrodynamic flow and signature control.

Tied to the hydrodynamic signature control is a continuing effort in evolving the SSN propulsor. This could go in several directions and would be tied to the development of electric drive.

TACTICAL SPEED IS IMPORTANT

- Maximum tactical speed is limited by radiated noise and sensor performance and determines mission efficiency
  - NSSN improved over Seawolf
- Transit time, and therefore maximum speed, is important less than 25% of a mission
- Escaping from weapons is helped by acceleration and maneuverability more than by speed
- Increases in tactical speed have more mission leverage than increases in flank speed.

Speed is also an important factor in submarine performance. Due to the relatively long transit times for US submarines to normal areas of operations, high maximum speed is an essential attribute in increasing time on station and/or getting to an emerging trouble spot.

Although the technological challenge associated with conducting evasive maneuvers with an object having the size and mass of a submarines is enormous, speed and acceleration will make a positive contribution to the ability of the submarine to escape weapons.

Radiated noise and sensor performance are the governing factors in establishing the maximum tactical speed. This parameter is a true discriminator among submarines and efforts to increase tactical speed deserve considerable attention. In fact, successful efforts to increase tactical speed will provide more mission leverage than efforts to increase flank speed.

SSN LAND ATTACK INCREASINGLY IMPORTANT

- Significantly improved target location and weapons effectiveness allows land attack to become an important SSN mission
- SSN based shore attack with the limited number of weapons carried will pivotal to an integrated campaign as the opening salvo
  - Geometry
  - Surprise
  - Flight time
  - Certainty of execution
- Large scale shore attack capability could be from converted Tridents

In addition to the traditional and historical missions accomplished by submarines, land attack has become a realistic and potent capability. As demonstrated during the Gulf War, attack submarines can make a valuable and significant contribution to destroying critical land targets.

In the future there is potential for land attack missions where it may be too risky to sail surface ships within range of the targets or there is a strong reason to retain the advantage of complete surprise. In these scenarios the SSN becomes the perfect launch platform. Its ability to sail within relatively close range of the target undetected furnishes it with unique ability to gain the element of surprise. Surprise is compounded by the potential for reduced flight time of the missiles due to the ability to covertly close the range to the minimum possible for sea based platforms. Finally the ability to stealthily penetrate to such advantageous launch positions, including favorable geometry to avoid terrain constraints, provides near certainty of successfully executing the mission. Despite the limited magazine capacity of the SSN, the foregoing attributes make the SSN a formidable vehicle for land attack as long as accurate targeting is available and precision munitions are used.

In the event increased magazine capacity is desired for submarine launched missile attacks, it is technically possible to convert Trident submarine missile silos to launch large numbers of missiles in the land attack mission.

LAND ATTACK (2)

- In a real campaign across sea/land interfaces this type of opening salvo is truly vital
- These factors imply land-attack payloads that should
  - Be precision, high confidence, preferably to designated aim-points.
  - Have multiple "front-end possibilities"
    - Integrated warhead
    - Cluster of smaller, single shot to kill "warheadlets"
    - Re-loadable, perhaps re-configurable selectable in-board
    - Special purpose payloads

The element of surprise in an opening salvo from an SSN allows targets to be attacked when their defenses are unprepared.

Depending on the specific circumstances there are a number of implications for land attack payloads. First they should be capable of precision targeting at designated aim-points with high confidence in their ability to perform the intended mission. Second, given the variety of circumstances that may be encountered, it would be highly desirable to provide a range of "front-end possibilities" on the missiles. For example, one might consider an integrated warhead, a cluster of single shoot to kill "warheadlets," or other special purpose warheads. Finally, it would be advantageous if the missiles could be reloadable or re-configurable on-board the submarine. This would provide the ability to revise the mission after the submarine was in theater, a very valuable attribute in a changing scenario.

APPENDICES

APPENDIX A: ACRONYMS AND ABBREVIATIONS

ACTD	Advanced Concept Technology Demonstration
ASDS	Advanced Swimmer Delivery System
ASW	Anti submarine warfare
ASUW	Anti surface warfare
ATD	Advanced Technology Demonstration
BPS	Bits per second
CINC	Commander-in-Chief
COMSUBDEVRON 12	Commander, Submarine Development Squadron 12
COMSUBLANT	Commander Submarine Force, US Atlantic Fleet
DARPA	Defense Advanced Research Projects Agency
DoD	Department of Defense
ELF	Extremely Low Frequency
FYDP	Future year defense plan
ID	Identification
LIDAR	Laser RADAR
NAVSEA	Naval Sea Systems Command
NSSN	New attack submarine
O&M	Operations and maintenance
PEO SUB	Program Executive Officer, Submarines
QDR	Quadrennial Defense Review
R&D	Research and development
SSBN	Submarine, nuclear ballistic missile
SSN	Submarine, nuclear attack
TMD	Theater missile defense
SOCOM	U.S. Special Operations Command
VLS	Vertical Launch System